

FURTHER STRATIGRAPHIC AND STRUCTURAL CONSTRAINTS ON THE ORIGIN OF THE BUSHVELD COMPLEX, SOUTH AFRICA. P.C. Buchanan^{1,2}, W.U. Reimold¹, and C. Koeberl². ¹Dept. of Geology, Univ. of the Witwatersrand, Private Bag 3, Wits 2050, Johannesburg, South Africa. ²Institute of Geochemistry, Univ. of Vienna, Althanstrasse 14, A-1090, Vienna, Austria.

SUMMARY. Based partly on its lobate shape, previous workers have suggested that the Bushveld Complex of South Africa and associated rocks are the result of multiple meteorite impacts. According to this interpretation, parts of the lower Rooiberg Group, rocks forming the roof of the Complex, represent a sheet of impact melt breccia. However, extensive field work throughout the Rooiberg Group, and particularly at the contact between this unit and the underlying Transvaal Supergroup, has failed to identify any material that could be interpreted as impact melt breccia or other impact breccia. The Rooiberg Group apparently is wholly composed of volcanic flows and pyroclastic units representing several magma types which display distinct geochemical signatures interbedded with thin, laterally extensive sedimentary units. Structural evidence suggests that the lobate shape of the Complex is the result of post-Bushveld deformation. These data along with the absence of macroscopic or microscopic evidence of shock deformation in pre-Bushveld rocks of the area are inconsistent with formation of the Complex by impact.

INTRODUCTION. Three hypotheses have been proposed for the petrogenesis of the Bushveld Complex, South Africa and the Rooiberg Felsite, which forms the roof of the intrusive Complex. One hypothesis [1,2] attributed both units to partial melting of mantle and lower crust by a mantle plume. A second hypothesis [3,4] interpreted the high magnesium felsites of the Rooiberg Group, which have silica-rich compositions similar to some sediments, as magmas formed by melting of detrital material subducted under southern Africa at a nearby plate margin. A third hypothesis [e.g., 5,6] attributed the origin of the Bushveld Complex and related rocks to multiple impacts of comets or meteorites. According to this interpretation, the lower Rooiberg Group represents a layer composed of impact melt breccia and other impact breccia, whereas the upper Rooiberg Group represents sedimentary strata, deposited during crater modification, interbedded with volcanic layers formed by extrusion of melt from the interior of the impact melt sheet before it had completely solidified. Analysis of the petrogenetic character of the Rooiberg Group based on geochemical, textural, stratigraphic, and structural data is critical to determine which of these three hypotheses is the most reasonable. This study is an attempt to evaluate the viability of the impact hypothesis for the Complex.

RESULTS. Rhodes [5] and Elston [6, also: pers. comm., 1996] suggested that impact-related materials are present in the lower Rooiberg Group. Elston [pers. comm., 1996] suggested that most of the impact melt breccia sheet was hidden below the intrusive Bushveld granites, but that at rare locations this material was observed in outcrop. Our field study has included an extensive investigation of the lower Rooiberg Group and, particularly, of the contact between the Dullstroom Formation (the lowest unit of the Rooiberg) and the underlying Transvaal Supergroup. This contact apparently represents the most distinct regional unconformity in this part of the stratigraphic column [7] and commonly is represented by amygdaloidal basalts and basaltic andesites overlying quartzite or hornfels. We could find no evidence at this contact or in the lower Rooiberg Group of autochthonous or allochthonous materials that might be interpreted as impact-related. However, at one location close to the Rooiberg-Transvaal contact, several loose boulders represent metasedimentary breccias composed of large irregular fragments of volcanic and metamorphic rocks, similar to some of the units found in the lower Rooiberg Group, contained as inclusions within a matrix-supported sandstone.

It was also noted during field study that boundaries between individual Rooiberg flow units, pyroclastic units, and sedimentary strata, which we assume were originally horizontal, are presently dipping at high angles [see also 8]. This is clearly seen in the lobe of the Complex near Loskop Dam (Fig. 1). The Rooiberg Group strikes east-west on the northern side of this lobe with dips toward the center of the lobe (south) ranging up to 80°. Along the eastern side of this lobe, Rooiberg strata strike north-south and dip 15°-30° to the west. Similar dips are also present in the post-Rooiberg Loskop Formation and in the lower part of the Waterberg Group in the same area; in contrast, upper Waterberg units in the center of the lobe have nearly horizontal orientations [8; also, R.G. Cawthorn, pers. comm., 1996]. Rooiberg strata also dip toward the centers of the other lobes of the Bushveld Complex. Calculations based on approximate dips and apparent thicknesses near Loskop Dam and in the eastern Bushveld suggest that actual thicknesses of the central and lower units of the Rooiberg Group are relatively constant throughout the area.

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DISCUSSION AND CONCLUSIONS. Buchanan and Reimold [9,10] have discussed certain aspects of the stratigraphy, structure, and mineralogy of the Rooiberg Felsite. Deformation lamellae found in some Rooiberg and pre-Rooiberg rocks are distinctly different from shock-characteristic planar deformation features (PDFs) and are of tectonic origin [also 11]. The presence in the lower Rooiberg of several geochemically distinct magma types as individual flows and pyroclastic units [2,7] interbedded with laterally extensive sedimentary units [12] precludes interpretation of most of this unit as a sheet of impact breccia. Relatively constant thicknesses of central and lower units of the Rooiberg suggest that these volcanic and sedimentary rocks were deposited on a relatively flat surface rather than on a surface with significant topographic relief as would be expected in an area affected by impact. Significant dips of units within the Rooiberg, the overlying Loskop Formation, and the lower part of the Waterberg Group indicate post-Bushveld deformation; the relationship of these dips with the present outcrop pattern of the Bushveld Complex suggests that lobate shapes were the result of this deformation. These data along with the absence of shatter cones, PDFs, and impact melt breccias or other impact breccias confirm the findings of Twist and French [13] and Buchanan and Reimold [9,10] that the hypothesis of formation of the Bushveld Complex by impact is not supported by the available evidence.

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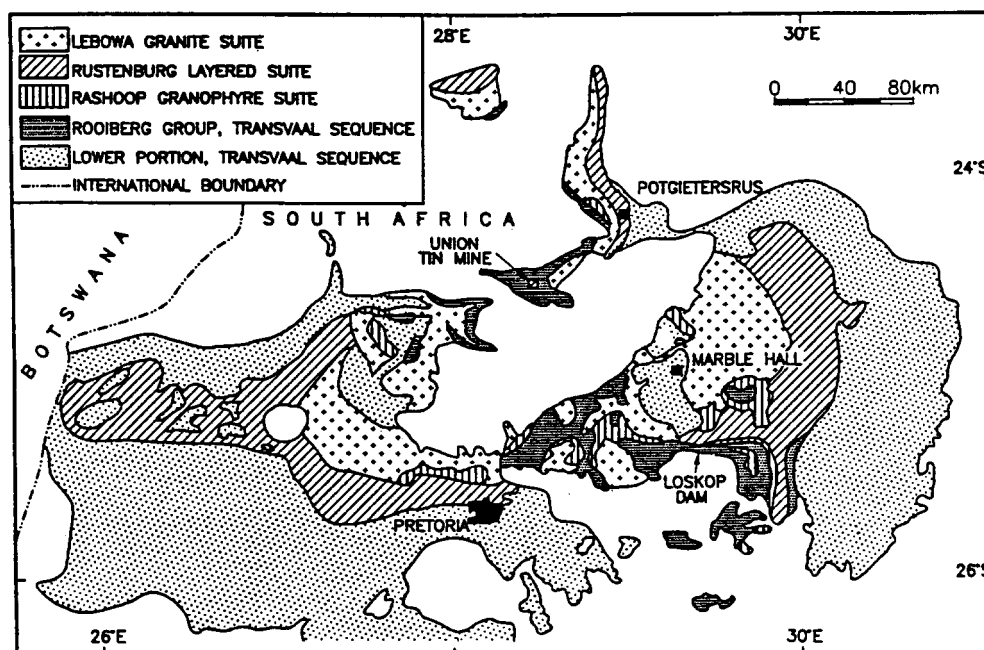


Fig. 1 Generalized geologic map of the Bushveld Complex after [7].